



Ames Culture Chamber System

Enabling Model Organism Research Aboard the International Space Station

Understanding the genetic, physiological, and behavioral effects of spaceflight on living organisms and elucidating the molecular mechanisms that underlie these effects are high priorities for NASA. Certain organisms, known as model organisms, are widely studied to help researchers better understand how all biological systems function. Small model organisms such as nematodes, slime mold, bacteria, green algae, yeast, and moss can be used to study the effects of micro- and reduced gravity at both the cellular and systems level over multiple generations. Many model organisms have sequenced genomes and published data sets on their transcriptomes and proteomes that enable scientific investigations of the molecular mechanisms underlying the adaptations of these organisms to spaceflight.

Culture chambers for conducting biological research during spaceflight using the European Modular Cultivation System (EMCS) Facility aboard the International Space Station were developed at NASA's Ames Research Center in Moffett Field, California. These culture chambers were used to perform multiple successful plant biology investigations aboard the station, including TROPI, TROPI-2, Plant Signaling and Seedling Growth-1. A team of researchers at Ames performed a study to determine whether these culture chambers can support the growth of a variety of model organisms.

Ames Culture Chamber Ground Testing with Model Organisms

The specimens tested were: nematode (*Caenorhabditis elegans*), bacteria (*Escherichia coli*), yeast (*Saccharomyces cerevisiae*), moss protonemata and spores (*Polytrichum* sp), slime mold (*Dictyostelium* sp), water bears/ tardigrades (*Hypsibius*

dujardini), and fern spores (*Ceratopteris thalictroides*).

These organisms were chosen for this study because they can survive periods of dehydration stasis, with later rehydration and growth. For space station research, this dehydration stasis period is highly desirable as it protects the science from negative effects of launch delays, launch forces, and delays of experiment initiation aboard the station. The Ames culture hardware includes a hydration system that is used to rehydrate organisms aboard the station at the start of each experiment. The hydration system is activated remotely by sending commands to the EMCS. For the model organism ground tests, the culture cassettes were hydrated by hand.

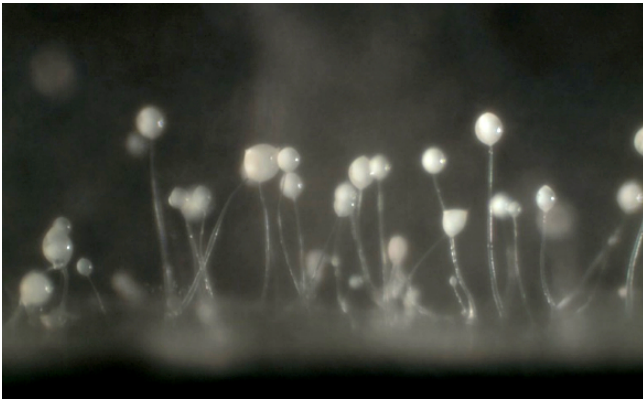


Laboratory microscope image of *Caenorhabditis elegans* that were dehydrated for 15 days, rehydrated, and grown for 7 days inside ARC EMCS culture cassettes. The image shows adults, juveniles, and egg clusters.

The ground tests were performed in culture cassettes using dehydrated specimens. As experimental controls, non-dehydrated specimens were also grown in the culture cassettes and under standard laboratory conditions.

Model Organisms Aboard the International Space Station

Without dehydration, all organisms displayed acceptable growth in the culture cassettes, as compared to those grown under standard laboratory conditions. Following various periods of dehydration, acceptable growth was also observed after rehydration of the organisms. For nematodes, tardigrades, and slime mold, food organisms were co-dehydrated and sustained the test organisms upon rehydration.



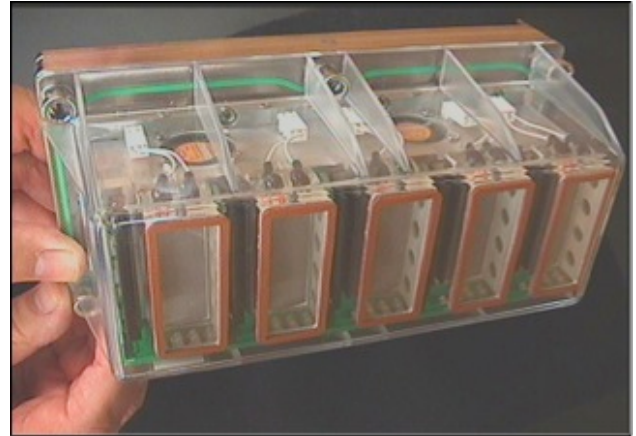
Dictyostelium discoideum dehydrated for 4 days, rehydrated, and grown for 9 days inside culture cassettes. This laboratory microscope image shows a lateral (side) view of fully differentiated fruiting bodies.

These data suggest that, with future experiment-specific testing, the Ames EMCS culture cassettes can be used with a wide variety of model organisms to conduct tightly controlled spaceflight experiments on the space station. These experiments will help to answer questions about the specific physiological responses of organisms during or after space flight.

The EMCS Facility

In collaboration with the European Space Agency, NASA's Ames Research Center is using the EMCS to perform life sciences research aboard the International Space Station. The EMCS is a unique incubator system that provides dedicated, controlled life support for biological experiments in a multi-gravity environment. Two independent centrifuge rotors inside the EMCS create gravitational forces ranging from 0 g (static rotor) to 2 g. This range

includes the g-forces found on the moon, Mars, and Earth. The EMCS allows direct comparison of fractional gravity and microgravity samples with 1 g control samples.



EMCS experiment container with Ames experiment unique equipment including five culture cassettes.

The modular component of the EMCS is an experiment container that mounts onto the centrifuge rotors. These experiment containers (four per rotor) hold experiment-specific hardware and provide gas, water, electrical and data connections to their contents from the EMCS. Each experiment container holds five culture chambers, each with cover-heaters to prevent condensation for imaging, LED lighting, and a hydration system.

During spaceflight experiments, images of the specimens are captured via rotor-mounted cameras according to a programmed schedule for downlink to Earth. At the end of the experiments, the culture cassettes can be frozen aboard the station at ultra-low temperatures, refrigerated, or chemically preserved before being returned to Earth for further analyses.

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